



0430  
03/26/02

45

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re patent application of  
Mark Ian Bingley

Serial No. 10/087,457

Filed March 1, 2002

For: ACTIVATED SLUDGE TREATMENT

**Attorney's Docket: 0126-024P/FLS**

Assistant Commissioner for Patents  
Washington, DC 20231  
Attn: Initial Examination

Sir:

We enclose for filing in the above application a certified copy of British Application No. 0105059.0, upon which priority is claimed.

Respectfully submitted,

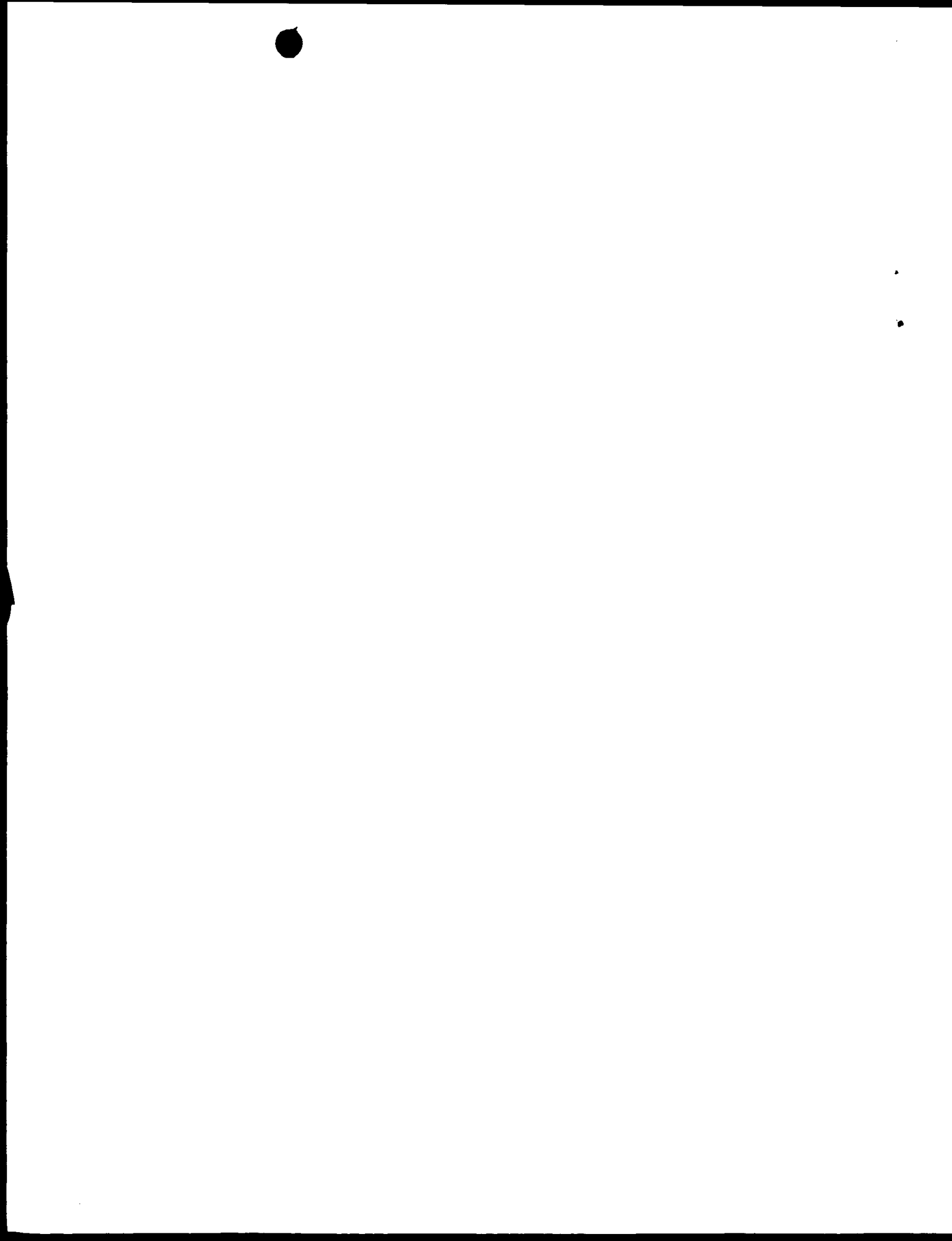
Fritz L. Schweitzer, Jr.  
Attorney for Applicant  
Registration No. 17,402

**Customer No. 022831**

Schweitzer Cornman Gross & Bondell LLP  
292 Madison Avenue – 19<sup>th</sup> Floor  
New York NY 10017  
Tel.: 646-424-0770  
Fax.: 646-424-0880

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, DC 20231, on the date indicated below.  
Date: March 15, 2002

Rosemarie Mannino





INVESTOR IN PEOPLE

The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

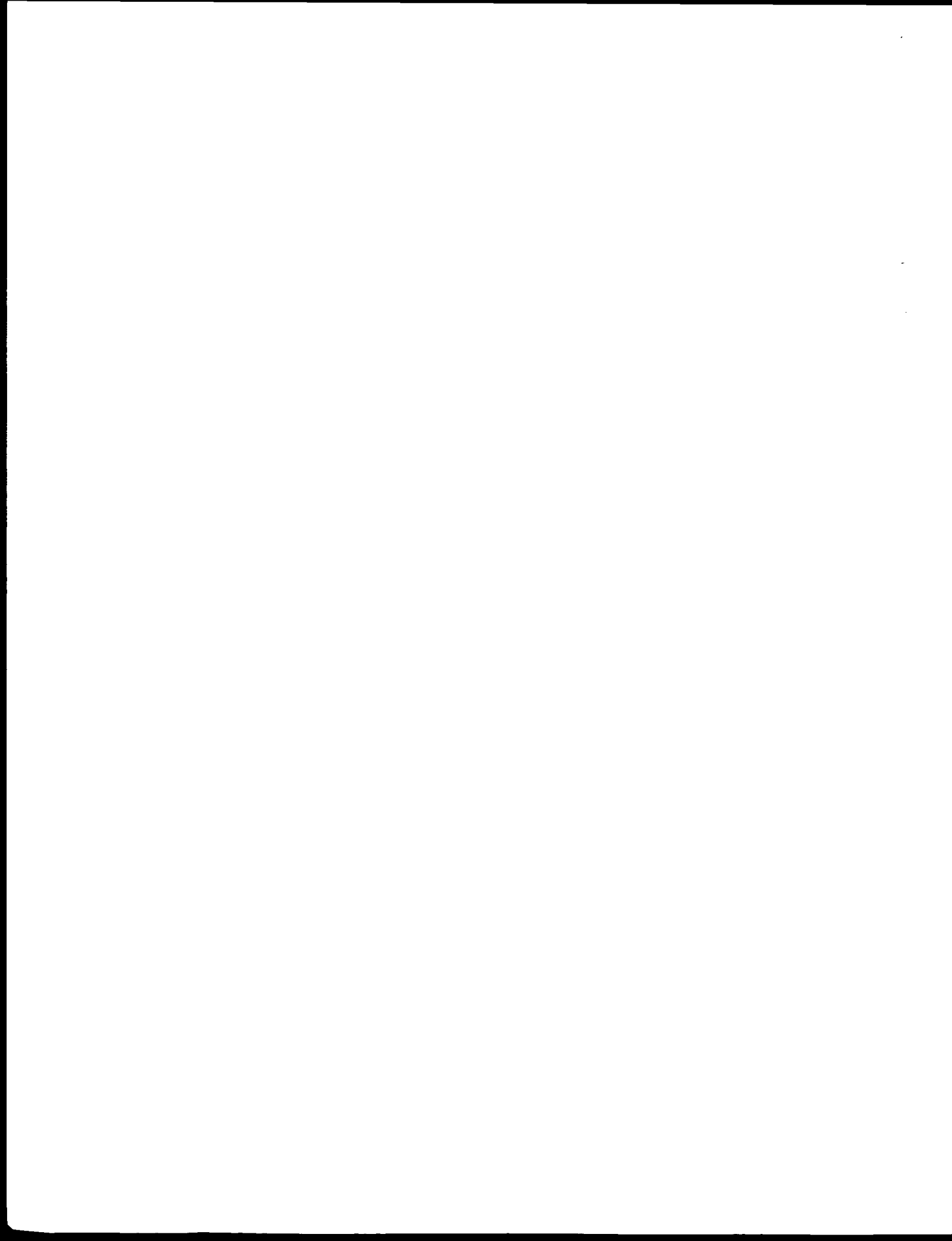
In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

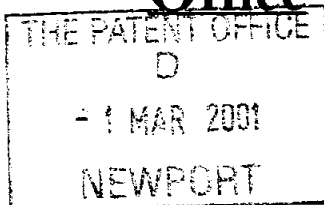
Signed 

Dated 8 February 2002



# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet, from the Patent Office to help you fill in this form)



The Patent Office

Cardiff Road  
Newport  
Gwent NP9 1RH

1.	Your reference	PMM2003	- 1 MAR 2001	
2.	Patent application number (The Patent Office will fill in this part)	<b>0105059.0</b>	01MAR01 E610095-13 002906 P01/7700 0.00 0105059.0	
3.	Full name, address and postcode of the or of each applicant ( <u>underline all surnames</u> )	Severn Trent Water Limited 2297 Coventry Road Birmingham B26 3PU		
	Patents ADP number (if you know it)	5612665001		
	If the applicant is a corporate body, give the country/state of its incorporation	England		
4.	Title of the invention	Activated Sludge Treatment		
5.	Name of your agent (if you have one)	Barker Brettell		
	"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	138 Hagley Road Edgbaston Birmingham B16 9PW		
	Patents ADP number (if you know it)	7442494002		
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number	Country	Priority application number (if you know it)	Date of Filing (day month/year)
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application		Date of filing (day month/year)
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))	Yes		

# Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form.  
Do not count copies of the same document  
Continuation sheets of this form

Description 9 + 9

Claim(s)

Abstract

Drawing(s) 2 + 2



10. If you are also filing any of the following, state how many against each item.  
Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination  
(*Patents Form 9/77*)

Request for substantive examination  
(*Patents Form 10/77*)

Any other documents  
(*please specify*)

11. I/We request the grant of a patent on the basis of this application.

Signature

  
**Barker Brettell**

Date

28/02/01

12. Name and daytime telephone number of person to contact in the United Kingdom

Miss Priscilla M. Makovski

Tel: 0121 456 1364

## Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

## Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 01645 500505
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

Patents Form 1/77

## ACTIVATED SLUDGE TREATMENT

This invention relates to activated sludge treatment of sewage.

5 There are various different types of apparatus in use for treating sewage by using activated sludge, which contains biological organisms in suspension to oxidise and stabilize the settled sewage, thus enabling the water to be removed. One type of apparatus is an oxidation ditch, which is normally used for relatively small quantities of sewage (up to a  
10 population equivalent of about 10,000). An oxidation ditch comprises an oval 'race-track', round which the sewage mixed with activated sludge (the mixed liquor) is circulated continuously and aerated by a rotor. As it goes round, the liquor is subjected to different processes, including aerobic and anoxic zones, and so shows gradients in dissolved oxygen,  
15 which ensures efficient treatment. The oxidation ditch normally includes a settlement zone for sludge. It is necessary for the liquor to be pumped round at a sufficiently slow speed for the various processes to operate properly, but at a sufficiently fast speed to ensure that the organisms remain in suspension. These two speeds are frequently impossible to  
20 reconcile.

Oxidation ditches therefore often have aerators operated on a timed basis, to provide the necessary aerobic and anoxic zones as a function of time rather than location on the 'race-track'. The ditch then becomes in effect  
25 a fully mixed reactor. The aerators are normally operated on a simple timed basis (a fixed ratio of on time to off time), but this does not take account of variations in load, i.e. the biological oxygen demand of the sewage coming in for treatment. The biological oxygen demand varies with the amount and condition of the sewage.

According to a first aspect of the present invention, in a fully mixed reactor providing activated sludge treatment of sewage as a mixed liquor and including at least one aerator operative intermittently to raise the dissolved oxygen level of the liquor, a control system is arranged to  
5 operate the aerator to provide an operative phase including a predetermined aerobic time period after a first dissolved oxygen target level is reached, and an inoperative phase including a predetermined anoxic time period after a second, lower, dissolved oxygen target level is reached.

10

As the control system operates the aerator in response to dissolved oxygen levels rather than on a simple timed basis, it can take account of variations in the load, and thus treat the sewage more effectively.

15 Preferably the operative phase comprises an initial variable time period and then the predetermined aerobic time period. The inoperative phase may comprise an initial variable time period and then the predetermined anoxic time period.

20 Thus, the aerator will be operative following the end of the predetermined anoxic time period, to take the dissolved oxygen level up to the first target level, and will then continue to operate for the predetermined aerobic time period to raise the dissolved oxygen level further, up to a given set point. At the end of the predetermined aerobic time period the  
25 control system switches the aerator off, initiating the inoperative phase. This allows the dissolved oxygen level to fall to the second lower target level, when the predetermined anoxic time period starts, during which the dissolved oxygen level falls further. At the end of the predetermined anoxic time period the control system starts the operative phase again by  
30 switching the aerator on. Thus, the control system only operates the



aerator when necessary, making the treatment process more efficient, and minimising the energy needed to operate the aerator.

The control system preferably includes at least one override condition, to  
5 assist in taking account of the variations in load. Thus, in an aerobic  
override condition, if the initial variable period of the operative phase is  
greater than a chosen multiple of the predetermined aerobic time period,  
the control system starts the inoperative phase. This condition may occur  
if the load is great (a large biological oxygen demand) so that the aerator  
10 has difficulty in raising the dissolved oxygen level to the first target  
level. As prolonged operation at intermediate dissolved oxygen levels,  
that is, between the target levels can give rise to problems, it is  
preferable to override the operative phase, and start the inoperative  
phase.

15

Conversely, in an anoxic override condition, if the initial variable period  
of the inoperative phase is greater than a chosen multiple of the  
predetermined anoxic time period, the control system starts the operative  
phase. This condition may occur if the load is weak (a small biological  
20 oxygen demand) so that the dissolved oxygen level drops slowly. Again,  
to avoid prolonged operation at the intermediate dissolved oxygen levels,  
it is preferable to override the inoperative phase and start the operative  
phase.

25 The predetermined time periods will be chosen according to the  
characteristics of each reactor, but the aerobic time period might be  
between 15 and 120 minutes, and typically of the order of 20 minutes,  
while the anoxic time period might be between 0 and 60 minutes, and  
typically of the order of 5 minutes.

30

Similarly, the target levels may also be chosen according to the reactor characteristics, but typically the first target level would be between 0.5 and 2.0 mg/L, while the second target level would be between 0.1 and 1.5 mg/L. The given set point might then be between 0.5 and 5.0 mg/L.

5

The multiples determining the override conditions will also be chosen to suit the particular reactor, but will be greater than 1, and in the range 2 to 10, but typically between 3 and 6.

- 10 According to a second aspect of the present invention, a method of controlling an aerator for a fully mixed reactor providing activated sludge treatment of sewage as a mixed liquor comprises operating the aerator in an operative phase including a predetermined aerobic time period after a first dissolved oxygen target level is reached, and in an inoperative phase  
15 including a predetermined anoxic time period after a second, lower, dissolved oxygen target level is reached.

Operating the aerator according to the method, in response to dissolved oxygen levels, means that the sewage is treated efficiently even with  
20 variations in the load.

The operative phase preferably comprises an initial variable time period and then the predetermined aerobic time period. The inoperative phase may comprise an initial variable time period followed by the  
25 predetermined anoxic time period.

The method may also include override steps, as described above in relation to the first aspect of the invention.

- 30 An embodiment showing both aspects of the invention is illustrated by way of example only in the accompanying drawings, in which:

**Figure 1** is a diagrammatic illustration of a plan view of a fully mixed reactor for activated sludge treatment of sewage; and

5        **Figure 2** is a graph plotting dissolved oxygen levels against time during operation of the reactor of Figure 1 according to the invention.

Figure 1 shows, in diagrammatic form, a fully mixed reactor 1 for  
10    activated sludge treatment of sewage. The reactor comprises a cuboid tank 2 containing activated sludge, into which settled sewage enters through an inlet 3. The activated sludge mixes with the settled sewage to form a mixed liquor 4. The activated sludge contains biological organisms in suspension, which oxidize and stabilize the settled sewage. This  
15    separates into sludge and a liquid effluent (more or less purified water) which is removed through an outlet 5 and clarified in a clarifier 25. The clarified water is then removed via outlet 26, whilst any return activated sludge is returned to the inlet 3 through a pipe 27. The biological organisms require a certain level of dissolved oxygen in the mixed liquor  
20    to oxidize the sewage, so that the reactor 1 must be operated with an aerobic phase, alternating with an anoxic phase to reduce the nitrification which can also occur.

The aerobic phase is achieved by turning on an aerator 6, comprising an  
25    electrically-operated fan 28 outside the tank 2 which blows air into the base of the tank 2 through a disc 29. The anoxic phase is achieved by keeping the aerator 6 turned off. The aerator 6 is operated by an electronic control system 7 in response to the dissolved oxygen content of the liquor 4 measured by a sensor 8, and for predetermined time periods.

The control system 7 includes an electronic memory 9 for storing information relating to the predetermined time periods and other process information, a timer 10 for measuring the time periods, and a processor unit 11 for processing the input from the timer 10, the memory 9 and the sensor 8, and delivering an output to operate the aerator 6. The information in the memory 9 is input by an operator according to the particular reactor.

The control system 7 switches the aerator 6 on for an operative phase, and then off for an inoperative phase.

In the operative phase the aerator 6 increases the dissolved oxygen level in the liquor 4. The reactor 1 has a dissolved oxygen set point 12 (see Figure 2), at which there is sufficient oxygen for the organisms to operate efficiently. The set point may vary from reactor to reactor, according to the tank size and the type of sewage being treated, i.e. the average biological oxygen demand of the sewage. The set point 12 will normally be between 0.5 and 5.0 mg/L, and is input into the memory 9 by the operator.

The memory 9 also holds a first target level 13 of dissolved oxygen, which is less than the set point 12, and again will be chosen according to the reactor characteristics. The first target level 13 will be in the range 0.5 to 2.0 mg/L, and is input by the operator.

In the operative phase the control system 7 switches on the aerator 6 for an initial variable period 14 until the first target level 13 is reached, and keeps it switched on for a predetermined aerobic time period 15 to provide the aerobic phase. At the end of the predetermined period the control system 7 switches off the aerator 6, starting the inoperative phase.

Switching off the aerator 6 causes the dissolved oxygen level to drop as the organisms use the oxygen. The inoperative phase has an initial variable period 16, lasting until a second lower dissolved oxygen target level 17 is reached. The second target level 17 is also held in the memory 9, and is chosen according to reactor characteristics. It will be in the range 0.1 to 1.5 mg/L, and is input by the operator. The inoperative phase concludes with a predetermined anoxic time period 18, after which the control system 7 switches the aerator 6 on again for the next operative phase.

10

The predetermined time periods 15, 18 are also held in the memory 9, and are chosen according to the reactor. The aerobic period 15 will normally be in the range 15 to 120 minutes, while the anoxic period 18 will normally be between 0 and 60 minutes.

15

The control system is also arranged to override normal operation of the aerator 6 if override conditions occur. These can occur in either the operative or the inoperative phase, where the initial variable period, in which the dissolved oxygen level is between the first and second targets, is too long. Prolonged operation at intermediate level between the first and second target levels 13, 17 can cause problems in the treatment process.

The initial variable period 14 of the operative phase may become too long if the load is too great, so that it has a biological oxygen demand that is too large to be supplied by the aerator 6. The control system 7 times the length of the initial variable period 14 using the timer 10, and if it exceeds a predetermined multiple of the predetermined aerobic time period 15, it overrides the normal operative phase, and turns the aerator 6 off, to initiate the inoperative phase. The multiple is normally in the range 2 to 10, and is chosen by the operator.

Conversely the initial variable period 16 of the inoperative phase may become too long if the load is weak, so that its biological oxygen demand is low, and the dissolved oxygen level drops very slowly. Again, the  
 5 timer 10 times the initial variable period 16 and if it exceeds a predetermined multiple of the predetermined anoxic time period 18, the control system 7 overrides the normal inoperative phase, and turns the aerator 6 on, to initiate the inoperative phase. The multiple is normally in the range 2 to 10, and is chosen by the operator.

10

The graph of Figure 2 shows the dissolved oxygen level plotted against time in hours of a reactor operating in accordance with the invention.

In Figure 2 the dissolved oxygen set point 12 is 2 mg/L, while the first  
 15 target level 13 is 1.5 mg/L, and the second target level 17 is 0.7 mg/L. the predetermined aerobic time period 15 is 20 minutes, with an override multiple of 5. The predetermined anoxic time period 18 is 5 minutes, with an override multiple of 4.

20 The point 20 on the graph represents the start of the inoperative phase, where the aerator 6 is switched off. The initial variable period 16 of the inoperative phase lasts until point 21, when the second target level 17 is reached. The predetermined anoxic time period 18 of 5 minutes then starts, during which the dissolved oxygen level drops further. Point 22  
 25 shows the end of the predetermined anoxic period 18, where the control system 8 switches the aerator 6 back on to start the operative phase.

The initial variable period 14 lasts until point 23, when the first target level 13 is reached. The operative phase continues with the predetermined  
 30 aerobic time period 13, ending at point 24, when the inoperative phase starts again.

It will be appreciated that, in modifications (not shown), the aerator 6 may be of a different type, where a rotor or venturi mixer is mounted within the tank 2. These aerators will be operated in a similar way to that  
5 described with reference to Figure 1.





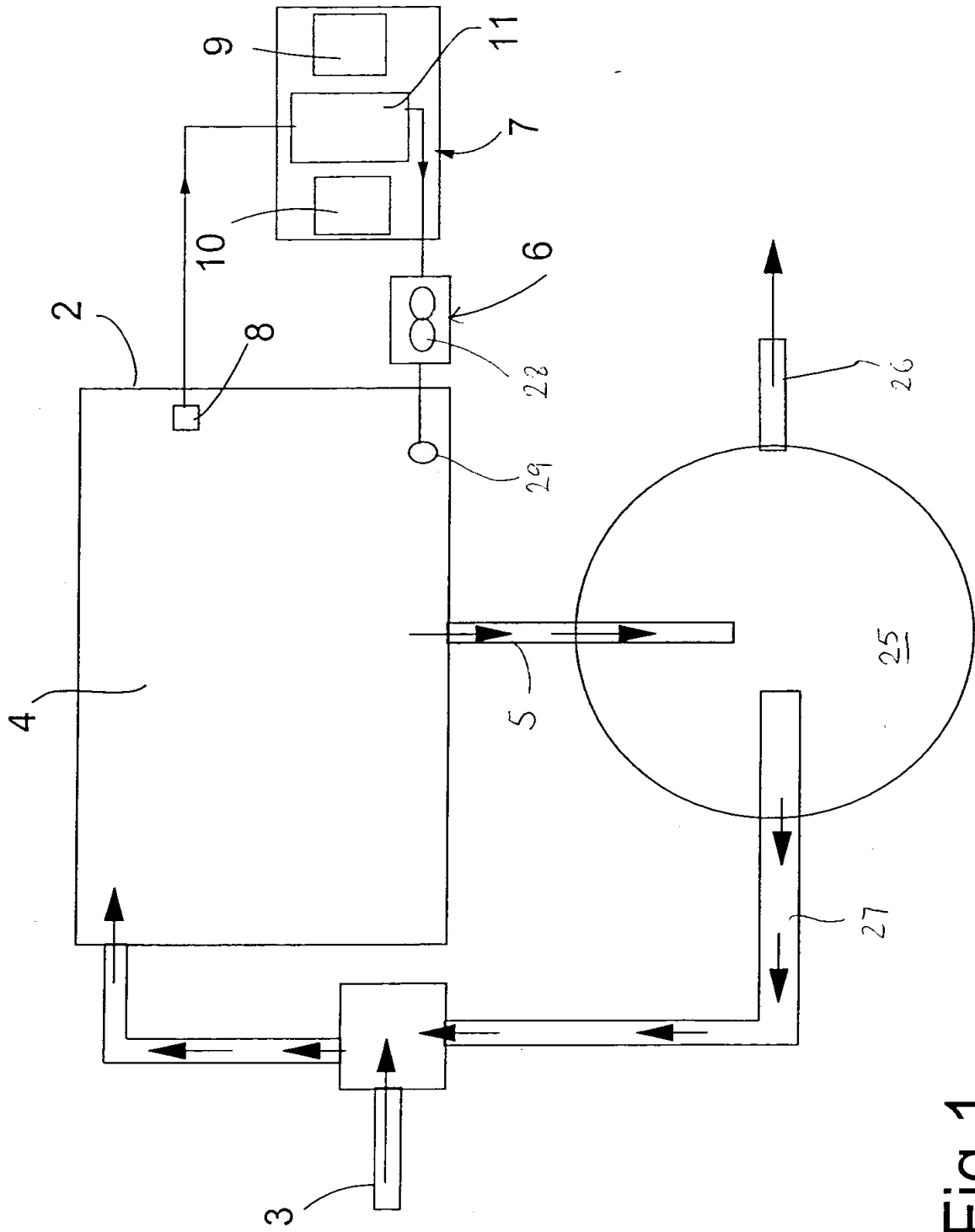


Fig 1



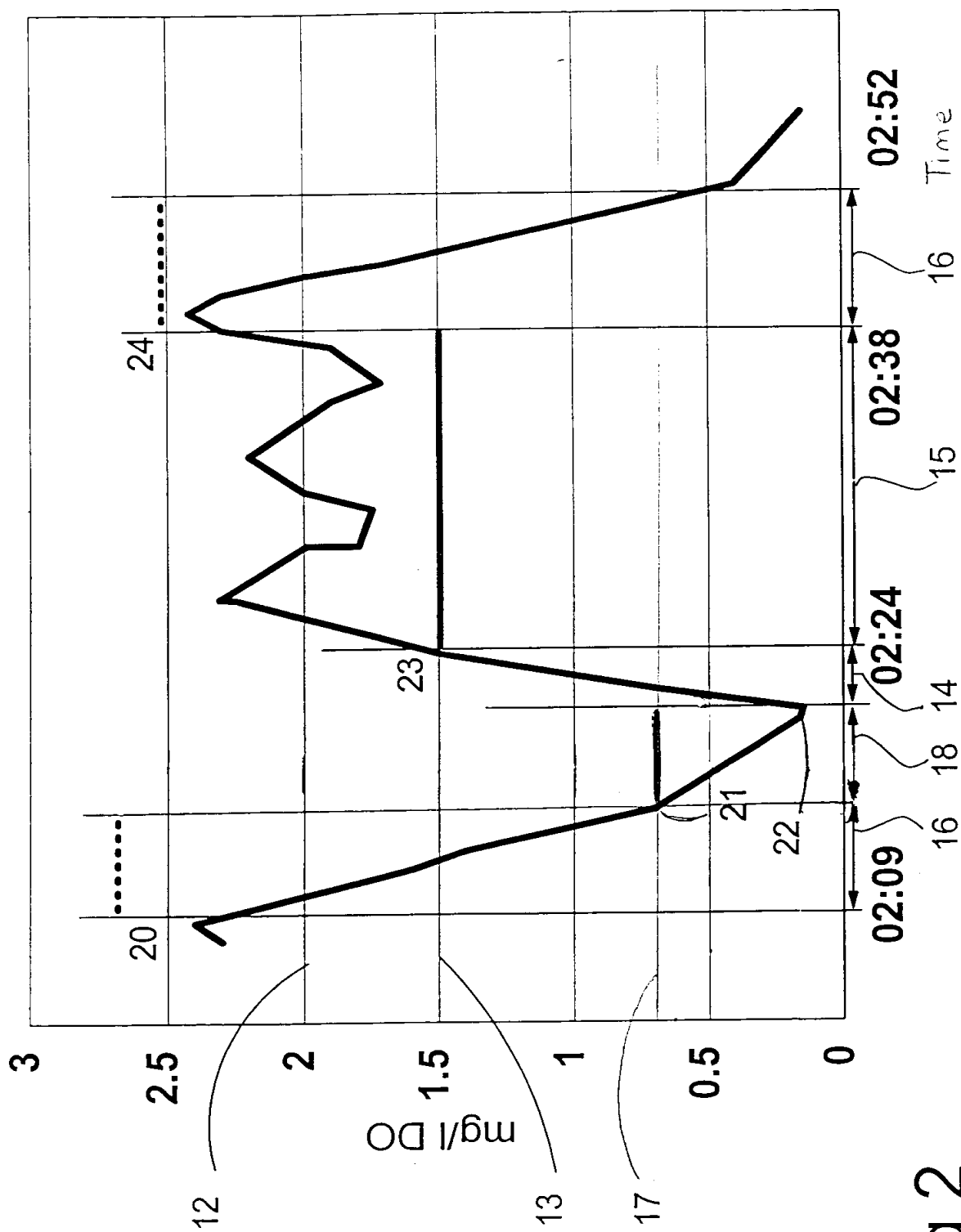


Fig 2

